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Effect of Boiling Time on the Change of Moisture Content, Color Analysis, and Granule's Shape of Breadnut (*Artocarpus camansi*) Flour

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ABSTRACT

Breadnut is a local product with a short shelf life that is not optimally processed and utilized in Indonesia. Breadnut is easily browning due to enzymatic activity. Meanwhile, breadnut potentially becomes an alternative product due to their nutritional value mainly carbohydrate. The aim of this study evaluate the effect of boiling time on the change of moisture content, color analysis, and granule shape of breadnut flour. Moisture content was analyzed using the gravimetric method the color analysis and shape of granules were using a color meter and digital microscope, respectively. Data was expressed of mean±SD while statistically analyzed using ANOVA with Duncan's test to determine the significant difference ($p<0.05$). The results of this study showed that the moisture content, L and b value of breadnut flour with boiling time of 10 and 15 minutes showed no significant difference ($p>0.05$). In addition, a* value did not significantly differ ($p>0.05$) for the breadnut with boiling times of 0 and 5 minutes. The granule's shape of breadnut under microspore was visualized and boiling time changed the size and shape of the granule due to heating and swelling. In conclusion, boiling time changed the moisture content, color analysis, and granule shape of breadnut flour.*

Keywords*: Breadnut, Boiling Time, Moisture, Color, Granule's Shape*

1. INTRODUCTION

Breadnut (*Artocarpus camansi*) is one of the plants widely grown in tropical countries such as Indonesia. It is commonly called Kluwih or Timbul in Indonesia. The genus Artocarpus is a family of Moraceae that comprises almost sixty species native to India, Southeast Asia, and Australasia [1]. Breadnut is similar to breadfruit, despite breadnut has rougher skin and seeds. Breadfruit is usually cultivated and utilized than breadnuts as flour [2]. Breadnut is qualified as a commodity with a unique flavor, high fiber, and carbohydrates [3]. The fruit is a syncarp that is covered with fleshly prickles or spines. Breadnut has a fibrous core with 50 to 100 seeds embedded in a white, flaky, and spongy pulp [4]. Breadnut is a highly perishable fruit with a short shelf life, not more than two days under ambient conditions [2].

Breadnut boasts anti-inflammatory, antioxidant, antifungal, and antibacterial potential [5]. In Indonesia, breadnut is usually processed into local foods by boiling and mixed with some spices [6]. Even though, several traditional foods use breadnuts as the main ingredient the price of breadnuts is still low in the market. Breadnut is easily browning due to enzymatic activity namely polyphenol oxidases [7]. Enzymatic browning naturally happens in fruits and vegetables when they are bruised, cut, peeled, diseases, or exposed to any abnormal

condition e.g. air. The brown color is a result of brown melanins from the oxidation of phenolic compounds [7]. Many studies reported that processing like steaming and boiling are simple ways to stop enzyme activity and also increase the quality of perishable commodities [8]. In addition, processing methods may have a good impact on increasing the value of breadnuts.

Drying is usually used to extend the shelf life of food products. According to Andriani et al., [9] drying was known to extend the shelf life of breadfruit and make it easier to use. Dried product like flour has been known to easy to be apply in many food products [10]. To produce good and efficient results, an oven is more commonly used to dry several products such as bananas, potatoes, and pumpkin flour [11], [12], [13]. The temperature of 60-70ºC for 6 hours was good enough to dry the food products becoming flour [14]. The advantages of using an oven are simpler tools, easy to use in a shorter time compared to traditional drying methods using the sun, and the temperature is adjustable so it does not damage the important components in the sample [15].

Flour is a dried product that potentially increases storage stability by converting native products to flour [5]. According to Rusliana et al. [16], the minimum moisture content of flour products is below 10%. Breadnut flour can be used as a mixture for making bread, cookies, noodles, and other foods. The advantage of food made from breadnut flour is that it has a low glycemic index compared to using other flour. In addition, breadnut flour also has advantages for health such as being gluten-free and rich in nutrients [17]. Unfortunately, the study related to the potential of breadnut as an alternative flour is still limited. Thus, the research was done to evaluate the effect of boiling time on moisture content, color analysis, and shape of granules.

2. METHOD

Materials

This study used several materials such as Breadnuts purchased from Blok A market, Indonesia then it was separated from the seeds and skin, iodin (ROFA Laboraorium Centre, Indonesia), and demineralized water (Cleo, Indonesia). Tools used in this study were pot (Maspion, Indonesia), stove (Maspion, Indonesia), Universal Drying Oven LDO-060E (Daihan Labtech Co., Korea), blender HR2222 (Phillips, China), digital microscope B-290TB (Optica, Japan), chromameter CR-410 (Konica Minolta, Japan), and 60 mesh siever (ABM, Indonesia).

Breadnut Flour Making [18]

Breadnut fruit that has been separated from its seeds and skin was thinly sliced (~2 mm). Breadnut has been thinly sliced was washed thoroughly. Then, the breadnut was boiled using demineralized water with the ratio 1:3 (w/v) in different boiling time treatments (0; 5; 10; 15 minutes), drained, and went into the cooling process by storage in the freezer at -24ºC for 24 hours. After that, the breadnut is dried using an oven at 60ºC for 6 hours. The dried breadnut was then crushed with a blender and sieved into flour.

Characterization of Breadnut Flour

Water Content [19]

Determination of water content in breadnut flour with different boiling times treatment is done by gravimetric method. The test cup was heated in an oven at 105°C for 30 minutes, cooled in a desiccator for 5 minutes, and weighed on an analytical balance. Then 5 grams of sample was put into a cup and weighed. The cup was then heated in an oven at 105°C, cooled in a desiccator for 5 minutes, and weighed. This process is carried out until the weight of the sample is constant. Water content is calculated using the following formula:

$$Water\ Content\ (\%) = \frac{a-b}{c} \times 100 \ldots\ldots\ldots (1)$$

a = mass of the cup and sample after heating (g)
b = mass of the cup (g)
c = mass of the sample before heating (g)

Flour Color [20]

Determination of color in breadnut flour with different boiling times treatments was carried out using a digital color meter or chromameter. Breadnut flour was put in a clear plastic before being analyzed. Samples that have been treated in the clear plastic are placed under the camera and after the measurement, the result of L*, a*, and b* values appear on the display screen.

Microscopic Analysis [21]

Determination of microscopic analysis in breadnut flour with different boiling times is done by the iodine staining method. 0.3 grams of starch was suspended in 15 mL of water and

stirred, and 3 mL of iodine solution in 85 mL of water was added rapidly. These suspensions were transferred into a microscope slide as much as one drop, covered with a cover, and brought into focus at 100× and 400 × magnifications.

Statistic Analysis

The data was expressed as mean values±standard deviation. Analysis of variance (ANOVA) was analyzed to observe the effect of boiling time on breadnut flour characteristics using one-way ANOVA. Follow-up tests were carried out using Duncan's test to determine the mean difference ($p<0.05$). Statistical analysis was performed using SPSS program 21.0.

3. Result and Discussions

Water Content

In this research, boiling and drying were carried out, to process breadnuts into breadnut flour. The treatment was conducted by boiling for 0, 5, 10, and 15 minutes, then stored in the freezer for 24 hours at -24ºC. Next, the breadnuts that had been stored in the freezer were dried using the oven at 60 for 4 hours. After boiling and the oven process, the moisture content contained in the breadnut becomes very low. Several research showed that flour has a long shelf life [22] while raw breadnuts normally only have a short shelf life of 1-2 days.

This research uses fresh breadnuts containing high water content, ~56±10.12% (data is not shown). High water content is a good place to breed spoilage, decreasing the nutritional value and damaging the ingredients [23]. Drying the row breadnut to flour by drying successfully decreased the percentage of water content (shown in Figure 1). In line, the percentage of moisture content in the breadnut flour was also low for all treatments. The data showed that increasing boiling time as well as increasing the moisture content however the percentage was still less than 10%. The highest and lowest moisture content in this study were 9.74±0.30% (boiling time of 15 minutes) and 7.31±0.23% (0 minute), respectively. Based on the treatments, both 10 and 15 minutes showed not significant difference ($p>0.05$).

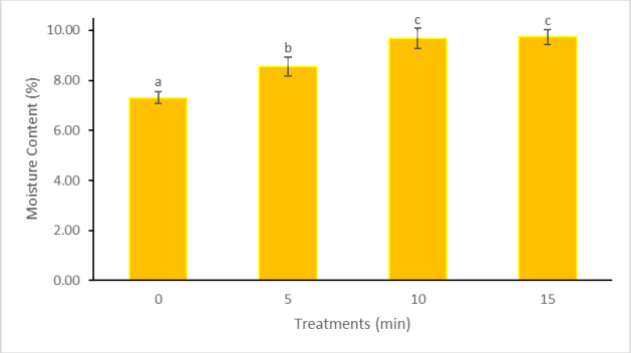

Figure 1. Moisture content (%) of breadnut flour in different boiling time
Note: Different annotations showed significant differences between the treatments ($p<0.05$)

The study of anchorite tuber with pretreatment of boiling times (60 and 80 minutes) before drying increased the moisture content of the flour sample (9.80 and 10.10%, respectively) [24]. According to Sundari et al., [25] drying row ingredients using the oven is affecting the reduction of water content in food ingredients. Heating during drying followed by time and temperature leads to an increase in the evaporation of water vapor [24]. The result of the study showed that the moisture content of breadnut flour was in the range of Standard Nasional Indonesia (SNI) No. SNI 01-3751-2006 for wheat flour with a maximal of 14.5% [26]. Wheat flour with a moisture content of less than 10% was suitable for extended shelf life [27].

Boiling treatment of 15 minutes contains higher moisture content due to several reasons. Firstly, during boiling the starch is gelatinized and absorbs water [28]. The boiling with excess water disrupted the hydrogen bonds between starch chains of both intra- and intermolecular. Afterward, free hydroxyl groups of amyloses long and amylopectin branch chains with water molecules form hydrogen bonds. Those processes contributed to an increase of damaging to crystalline structure with the absorption of water from the environment into the granule crystalline regions [29]. It is followed by the leaching out of the granule that results in an increasing granular swelling [30].

Flour Color

Color analysis in this research was done by using a chromameter. Analysis was carried out with the color system. The color of food is important to consumer acceptance of these foods.

The color reflected light on the surface of a material that is captured by the sense of sight and transmitted to the nervous system. Color testing with a chromameter has the principle of getting a color based on the reflectivity of the sample. The color system used is the Hunter's Lab Colorimetric System which is characterized by three values, namely L (Lightness), a* (Redness), and b* (Yellowness). The L, a, and b values have scale intervals that indicate the color level of the material being tested. The L notation states the brightness parameter with a range of values from 0-100 indicating from dark to light. The notation a (Redness) with a range of values from (-80) - (+100) indicates from green to red. The notation b (yellowness) with a value range from (-70) - (+70) indicates from blue to yellow (31).

The value of color analysis was presented in Table 1 for all treatments; boiling time 0, 5, 10, and 15 minutes. The L values of all treatments were increased following the boiling time which boiling time increased the light of breadnut flour. The higher value of L was 72.31 for a boiling time of 10 minutes while the lower value of L was 64.67 for a boiling time of 0 minutes. The L value of boiling of 10 minutes had a higher value than 15 minutes however both of the treatments did not show any significant difference ($p>0.05$).

Table 1. Color Analysis Of Breadnut Flour In Different Boiling Time

Treatments (min)	L	a*	b*
0	64.67±0.42^{a}	1.40±0.26^{c}	33.17±1.15^{c}
5	69.32±0.99^{b}	0.97±0.32^{c}	29.53±0.32^{b}
10	72.37±0.05^{c}	-1.53±0.42^{b}	21.23±0.35^{a}
15	72.01±0.83^{c}	-2.57±0.47^{a}	21.30±0.36^{a}

Note: Data was shown as mean±SD, different annotation showed significant difference between treatments ($p<0.05$)

The value of a* and b* showed in a similar pattern whereas the value decreased following the boiling time (shown in Table 1). The higher values of a* and b* were from boiling time of 0 minutes (1.40 and 33.17, respectively) while the lower values of a* and b* were from 15 minutes (-2.57 and 21.30, respectively). The boiling time of 0 and 5 minutes showed no significant difference ($p>0.05$) for a* while the boiling time of 10 and 15 minutes showed no significant difference ($p>0.05$) for b*. According to the a* and b * analysis, boiling time made on the change of breadnut flour becomes more green and yellow.

Breadnut flour obtained from increasing boiling time followed by oven drying had decreased the a* and b* values. The change of L, a*, and b* values in breadnut flour after boiling treatment were due to inactivation and inhibition of enzymatic browning [32]. According to Murayama et al., [33] the* and b* values were higher due to more exposure to heating. A temperature of more than 50°C and a suitable time for heating allows the decrease of enzymatic browning which destroys at 80°C [34]. Supported by Agblor and Scanlon [35] found that a short time blanching increases lightness. In addition, sorghum flour was reported to increase L value after heated treatment.

Microscopic Analysis

Microscopy analysis was carried out to evaluate the effect of boiling time on the granule shape of breadnut flour (shown in Figure 2). The results showed the image with a boiling time of 0 minutes contained rich granules with a round shape despite of small size. Then, a boiling time of 5 minutes captured swollen granules with a similar shape to the native. The change of granule shape happened in the boiling time of 10 and 15 minutes in which the granules were broken, and the surface of granules was surrounded by leached soluble materials

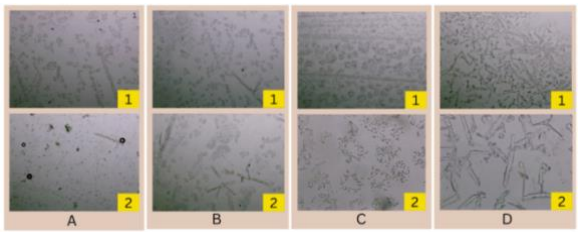

Figure 2. Microscopic analysis of breadnut flour in different boiling times: (A) 0 minutes, (B) 5 minutes, (C) 10 minutes, (D) 15 minutes; under the microscope in (1) 100×, (2) 400× magnifications

The boiling process that occurred changed the form of breadnut starch. The boiling process allowed water molecules to penetrate the starch granules and cause the starch granules to swell

[36]. The boiling was done, more water would enter, causing the starch granules to break and eliminate the shape of the starch granules as a whole [37]. Excess water disrupted the hydrogen bonds between starch chains of both intra- and intermolecular. Free hydroxyl groups of amyloses long and amylopectin branch chains with water molecules form hydrogen bonds. Those processes contributed to the increase of damaging to crystalline structure with the absorption of water from the environment into the granule crystalline regions [29]. This can be seen from the results of breadnut flour after boiling for 5 minutes where the starch becomes swollen and after boiling for 10 minutes the granules burst.

Starch that is ruptured can be reduced in quantity due to starch dissolving in the cooking water and is wasted when the breadnut is drained [38]. This explains why the number of granules of breadnut flour that were boiled for 10 and 15 minutes have fewer granules inside compared to other treatments. The granules broke after boiling for 10 minutes and after 15 minutes, the starch granules were carried away by the boiling water. During the treatments, it predicts that an increase in resistant starch happened in this study. The limitation of this study does not evaluate the production of resistant starch in every treatment.

4. CONCLUSION

The increase in boiling time was affected by the change in breadnut flour characteristics. Moisture content was increasing in line with the boiling time followed by an increase of L and b* values while the a* value was decreasing. The granule shape was also swell and broke together with the boiling time as well and the granule leach out in the water.

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REFERENCES

[1] Bakar A, Bakar A. Tarap—Artocarpus odoratissimus. *In: Exotic Fruits Reference Guide*. 2018.

[2] Mohammad M, Wickham L. Breadnut (Artocarpus camansi Blanco). *In: Postharvest Biology and Technology of Tropical and Subtropical Fruits.* Woodhead Publishing Series in Food Science, Technology and Nutrition; 2011. p. 272–89.

[3] Mohammed M, Wickham L. Breadnut (Artocarpus camansi Blanco): A review of postharvest physiology, quality management, processing and utilization. *J Hortic Postharvest Res*. 2021;4(2).

[4] Mohammed M, Wickham L. Physiological manifestations of chilling injury in breadnut (Artocarpus camansi Blanco). *Trop Agric*. 2016;93(5).

[5] Alcon CLM, Barrion ASA, Nguyen-Orca MF. Proximate Composition, Antioxidant Capacity and Functional Properties of Breadnut Seed Flour (Artocarpus camansi). *Turkish J Agric - Food Sci Technol*. 2021;9(8):1495–9.

[6] Ramadani FN. PENAMBAHAN BUAH KLUWIH (Artocarpus communis) DAN GULA SEMUT PADA PEMBUATAN ABON KEONG BAKAU (Telescopium Telescopium) . [Pangkep]: *POLITEKNIK PERTANIAN NEGERI PANGKAJENE KEPULAUAN*; 2020.

[7] Jiang Y, Duan X, Qu H, Zheng S. Browning: Enzymatic Browning. *In: Encyclopedia of Food and Health*. 2015.

[8] Alfy A, Kiran B V., Jeevitha GC, Hebbar HU. Recent Developments in Superheated Steam Processing of Foods—A Review. *Crit Rev Food Sci Nutr*. 2016;56(13).

[9] Andriani M, Anandito BK, Nurhartadi E. PENGARUH SUHU PENGERINGAN TERHADAP KARAKTERISTIK FISIK DAN SENSORI TEPUNG TEMPE"BOSOK". *J Teknol Has Pertan.* 2013;6(2).

[10] Chen RY, Wang Y, Dyson D. Breadings-What They Are and How They Are Used. *In: Batters and Breadings in Food Processing*. 2011.

[11] Alam M, Biswas M, Hasan MM, Hossain MF, Zahid MA, Al-Reza MS, et al. Quality attributes of the developed banana flour: Effects of drying methods. *Heliyon*.

2023;9(7).
[12] Bao H, Zhou J, Yu J, Wang S. Effect of drying methods on properties of potato flour and noodles made with potato flour. *Foods*. 2021;10(5).
[13] Aljahani AH. Wheat-yellow pumpkin composite flour: Physico-functional, rheological, antioxidant potential and quality properties of the pan and flatbread. *Saudi J Biol Sci*. 2022;29(5).
[14] Sari DK, Lestari RSD. THE PRODUCTION OF BREADFRUIT FLOUR: EFFECT OF HEATER TEMPERATURE ON THE DRYING RATE AND TIME OF THE BREADFRUIT. *J Bahan Alam Terbarukan*. 2017;6(1).
[15] Wahyuni R, Guswandi HR. Pengaruh Cara Pengeringan Dengan Oven, Kering Angin dan Cahaya Matahari Langsung Terhadap Mutu Simplisia Herba Sambiloto. *Fak Farm Univ Andalas Sekol Tinggi Ilmu Farm Padang*. 2014;6(2).
[16] Rusliana E, Saleh M, Yusnaini Y. Model Hubungan Antara Pengeringan Oven Terhadap Nilai Kapasitansi, Kadar Air dan Rendemen Biji Pala (Myristica Fragrans Houtt). *J Pros Ind Res Work Natl Semin*. 2022;13(1):25–31.
[17] Liu Y, Brow PN, Ragone D, Gibson DL, Murc SJ. Breadfruit flour is a healthy option for modern foods and food security. *PLoS One*. 2020;15(7 July).
[18] Putra INK, Suparthana IP, Ina NPT. Physicochemical properties and microstructure of the pregelatinized tannia flour prepared by a simple parboiling method. *Asian J Agric Biol*. 2020;8(2).
[19] Fikriyah YU, Nasution RS. Analisis Kadar Air Dan Kadar Abu Pada Teh Hitam yang Dijual di Pasaran dengan Menggunakan Metode Gravimetri. *Amina.* 2021;3(2).
[20] Al-Baarri N, Widayat, Cahyono B, Anditasari BN, Khairunnisa U, Pangestika W. The Color Analysis of Noodle Made from Modified Cassava Flour. *In: IOP Conference Series: Earth and Environmental Science*. 2020.
[21] Apparatus S. The method applies to all starches but is intended especially for the identification of separated, unmodified, native, or commercial starches. *Corn Refiners Assoc*. 2018;1–8.
[22] Forsido SF, Welelaw E, Belachew T, Hensel O. Effects of storage temperature and packaging material on physico-chemical, microbial and sensory properties and shelf life of extruded composite baby food flour. *Heliyon*. 2021;7(4).
[23] Mannheim CH, Liu JX, Gilbert SG. Control of water in foods during storage. *J Food Eng.* 1994;22(1–4).
[24] Bikila AM, Tola Y, Esho TB, Forsido SF. Effect of pre-drying treatment and drying temperature on proximate composition, mineral contents, and thermophysical properties of anchor (Coccinia abyssinica (Lam.) Cogn.) flour. *Food Sci Nutr.* 2020;8(10).
[25] Sundari D, Almasyhuri A, Lamid A. Pengaruh Proses Pemasakan Terhadap Komposisi Zat Gizi Bahan Pangan Sumber Protein. *Media Penelit dan Pengemb Kesehat*. 2015;25(4).
[26] SNI. Tepung terigu sebagai bahan makanan. Indonesia: Badan Standardisasi Nasional; 3751, 2009. p. 1–48.
[27] Nasir M, Butt MS, Faqir M A, Sharif K, Minhas R. Effect of Moisture on the Shelf Life of Wheat Flour. *Int J Agric Biol.* 2003;5(4).
[28] Tran T, Zhang X, Ceballos H, Moreno JL, Luna J, Escobar A, et al. Correlation of cooking time with water absorption and changes in relative density during boiling of cassava roots. *Int J Food Sci Technol.* 2021;56(3).
[29] Sangwongchai W, Tananuwong K, Krusong K, Natee S, Thitisaksakul M. Starch Chemical Composition and Molecular Structure about Physicochemical Characteristics and Resistant Starch Content of Four Thai Commercial Rice Cultivars Differing in Pasting Properties. *Polymers (Basel)*. 2023;15(3).
[30] Kong X, Zhu P, Sui Z, Bao J. Physicochemical properties of starches from diverse rice cultivars varying in apparent amylose content and gelatinization temperature combinations. *Food Chem*. 2015;172.
[31] Indrayati F, Utami R, Nurhartadi E. Pengaruh penambahan minyak atsiri kunyit putih (Kaempferia rotunda) pada edible coating terhadap stabilitas warna dan pH fillet ikan patin yang disimpan pada suhu beku. *J Teknosains Pangan*. 2013;2(4).
[32] Mesquita VLV, Queiroz C. Chapter 10 – Enzymatic Browning. In: Biochemistry of

Foods. 2013.

[33] Murayama D, Kimura T, Tsuboi K, Yamada D, Santiago DM, Koaze H, et al. Applicability of dry flours produced from a table potato variety (Solanum tuberosum L. cv. May Queen) in bread making. *Food Sci Technol Res*. 2015;21(3).

[34] Severini C, Baiano A, De Pilli T, Romaniello R, Derossi A. Prevention of enzymatic browning in sliced potatoes by blanching in boiling saline solutions. *LWT*. 2003;36(7).

[35] Agblor A, Scanlon MG. Processing conditions influencing the physical properties of French fried potatoes. *Potato Res*. 2000;43(2).

[36] Utama CS, Sulistiyanto B, Kismiyati S. THE EFFECTS OF WATER ADDITION AND STEAMING DURATION ON STARCH COMPOSITION OF WHEAT POLLARD. *Reaktor*. 2018;17(4).

[37] Xie X, Qi L, Xu C, Shen Y, Wang H, Zhang H. Understanding how the cooking methods affected structures and digestibility of native and heat-moisture treated rice starches. *J Cereal Sci*. 2020;95.

[38] Rosanna, Octora Y, Basuki Ahza A, Syah D. Prapemanasan Meningkatkan Kerenyahan Keripik SingkongDan Ubi Jalar Ungu. *J Teknol dan Ind Pangan.* 2015;26(1).